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## UMENTATION PAGE

Form Approved
OMB No. 0704-0188

| | |
|---|---|
| 1b RESTRICTIVE MARKINGS | |
| 2a SECURITY CLASSIFICATION AUTHORITY | 3 DISTRIBUTION/AVAILABILITY OF REPORT: Unlimited |
| 2b DECLASSIFICATION/DOWNGRADING SCHEDULE | |
| 4 PERFORMING ORGANIZATION REPORT NUMBER(S) | 5 MONITORING ORGANIZATION REPORT NUMBER(S) |
| 6a NAME OF PERFORMING ORGANIZATION: Stanford University | 6b OFFICE SYMBOL (If applicable): |
| 6c ADDRESS (City, State, and ZIP Code): c/o Sponsored Projects Office, Encina Hall, 660 Arguello Way, Stanford, CA 94305 | 7a NAME OF MONITORING ORGANIZATION: Department of the Navy, Office of Naval Research |
| | 7b ADDRESS (City, State, and ZIP Code): 800 North Quincy Street, Arlington, VA 22217-5000 |
| 8a NAME OF FUNDING/SPONSORING ORGANIZATION: Office of Naval REsearch | 8b OFFICE SYMBOL (If applicable): N00014 |
| 8c ADDRESS (City, State, and ZIP Code): 800 North Quincy Street, Arlington, VA 22217-5000 | 9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: N00014-89-J-1815 |
| | 10 SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO; PROJECT NO; TASK NO; WORK UNIT ACCESSION NO |

11 TITLE (Include Security Classification)

Computing Methods for the Approximate Solution of Time Dependent Problems

12 PERSONAL AUTHOR(S)
Joseph Oliger

| 13a TYPE OF REPORT | 13b TIME COVERED | 14 DATE OF REPORT (Year, Month, Day) | 15 PAGE COUNT |
|---|---|---|---|
| FINAL | FROM 07/89 TO 09/93 | 11/94 | 5 |

16 SUPPLEMENTARY NOTATION

| 17 COSATI CODES | | | 18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number) |
|---|---|---|---|
| FIELD | GROUP | SUB-GROUP | |
| | | | |
| | | | |

19 ABSTRACT (Continue on reverse if necessary and identify by block number)



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DD Form 1473, JUN 86 — Previous editions are obsolete — SECURITY CLASSIFICATION OF ...

S/N 0102-LF-014-6603

# FINAL REPORT

Contract Title: "Computing Methods for the Approximate Solution of Time Dependent Problems"

Principal Investigator: Joseph Oliger, Dept. of Computer Science, Stanford University

Contracting Agency: Office of Naval Research

Contract Number: Department of the Navy N00014-89-J-1815

Contract Period: 1 July 1989 through 30 September 1993

## PROJECT OVERVIEW

The research dealt with computing methods for applications in aerodynamics, geophysics, hydrodynamics, meteorology, and oceanography. Analysis was done of adaptive numerical methods for time-dependent problems in complicated physical domains which can efficiently and reliably approximate singular and near singular features of the solution such as fronts and shocks. Work focused on development of algorithms which could be executed on parallel architectures and upon data structures and language constructs which allow this to be done efficiently and effectively.

1. Algorithm Development

A new approach to establishing stability of numerical methods for initial boundary value problems which is much easier to verify was completed and will appear in Gustafsson, Kreiss and Oliger (1995).

The design of effective composite adaptive grid methods was completed, see Oliger CLASSiC Manuscript 91-26. A method and theory for error control for these methods was also completed, see Oliger and Zhu (to appear).

Composite grid methods were successfully used to simulate mechanical flows by van der Wijngaart (1990).

A new class of globally convergent optimization methods for the solution of the variational problem for elliptic partial differential equations was developed and analyzed by Behrman (to appear).

2. Data Structures, Communication Systems, and Language Constructs

A system and language environment for scientific computing was designed, see Oliger CLaSSiC Manuscript 91-27. The user interface of this system was implemented in the thesis of Pichumani (1991). The language VORPAL, designed to easily implement data structures for composite adaptive grid methods is being implemented in the thesis of Suhr (to appear). Formal definitions of these data structures were developed in Pichumani, Oliger and Venkata (1991).

Papers and Presentations

Invited Presentations:

"Composite Grids for Flow Computations on Complex 3D Domains", Ramana G. Venkata, Joseph Oliger, Joel Ferziger, *Proceedings of the Fifth SIAM Conference on Domain Decomposition Methods for Partial Differential Equations*, May 6-8, 1991, Norfolk, VA.

"Three-dimensional Composite Grid Generation using Bezier Family of Curves and Surfaces", Ramana G. Venkata *Second SIAM Conference on Geometric Design*, Nov. 4-8, 1991, Tempe, AZ

Books/Chapters In-Process/Published:

Bertil Gustafsson, Heing Otto-Kreiss, and Joseph Oliger, *Time Dependent Problems and Difference Methods*, John Wiley & Sons 1995.

J. Oliger, "Adaptive component methods for time dependent PDEs," in *Proceedings of the Complete Modeling System Computatational Technology Workshop*,, published by Science and Technology Management.

Publications and Reports:

Joseph Oliger, Ramani Pichumani, and Dulce Ponceleon, "A visual object-oriented unification system", CLaSSiC Manuscript 89-23, 1989.

Ramani Pichumani, Joseph Oliger, and Ramana Venkata, "Symbolic expressions of composite grid structures", CLaSSiC Manuscript 91-25, 1991.

Joseph Oliger, "Adaptive component methods for time dependent PDE's", CLaSSiC Manuscript 91-26, 1991.

Joseph Oliger, "A system and language environment for scientific computing", CLaSSiC Manuscript 91-27, 1991.

Ramana Venkata, Joseph Oliger, and Joel Ferziger, "3D composite grids for flow computations: the grid generation", CLaSSiC Manuscript 91-28, 1991.

Ramana Venkata, Steven Suhr, Joseph Oliger, and Joel Ferziger, "3D composite grids using Bezier curves and surfaces in component adaptive methods", CLaSSiC Manuscript 93-32, 1993.

Joseph Oliger and Xiaolei Zhu, "Stability and error estimation for component adaptive grid methods," to appear in *J. Comp. and Appl. Math.*

Theses:

Ramani Pichumani, *A Visual Object-Oriented Unification System*, Stanford University, January 1991. (Engineer's Degree)

Robertus Franciscus van der Wijngaart, *Composite-Grid Techniques and Adaptive Mesh Refinement in Computational Fluid Dynamics*, Stanford University, January 1990. (Ph.D. Dissertation)

William Behrman, *A New Method for Unconstrained Nonlinear Optimization and the Solution of Variational Partial Differential Equations*, to appear. (Ph.D. Dissertation)

Steven Suhr, *A Programming Language for Scientific Computing, Applied to Adaptive Grid Generation*, to appear. (Ph.D. Dissertation)

Stanford Personnel Supported

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